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(54) Liquid-gas separator

(57) A pipeline carrying gas and liquid, wherein the liquid may form slugs filling the whole cross-section, has an expansion chamber 4 wherein the liquid and gas are separated, led through separate outlets 13, 7 and recombined to form a homogeneous mixture. The outlets have respective restrictions 15, 9. In Fig. 2 a perforate section of pipeline extends through the chamber, to enable spherical pigs to be propelled therethrough for cleaning purposes. In Fig. 3 the two flows recombine inside the chamber.

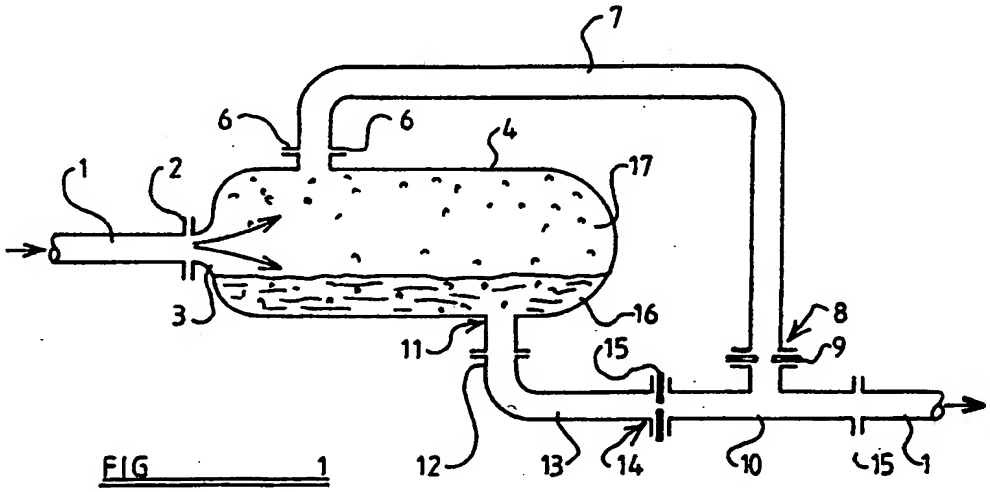

FIG 1

GB 2 239 193 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

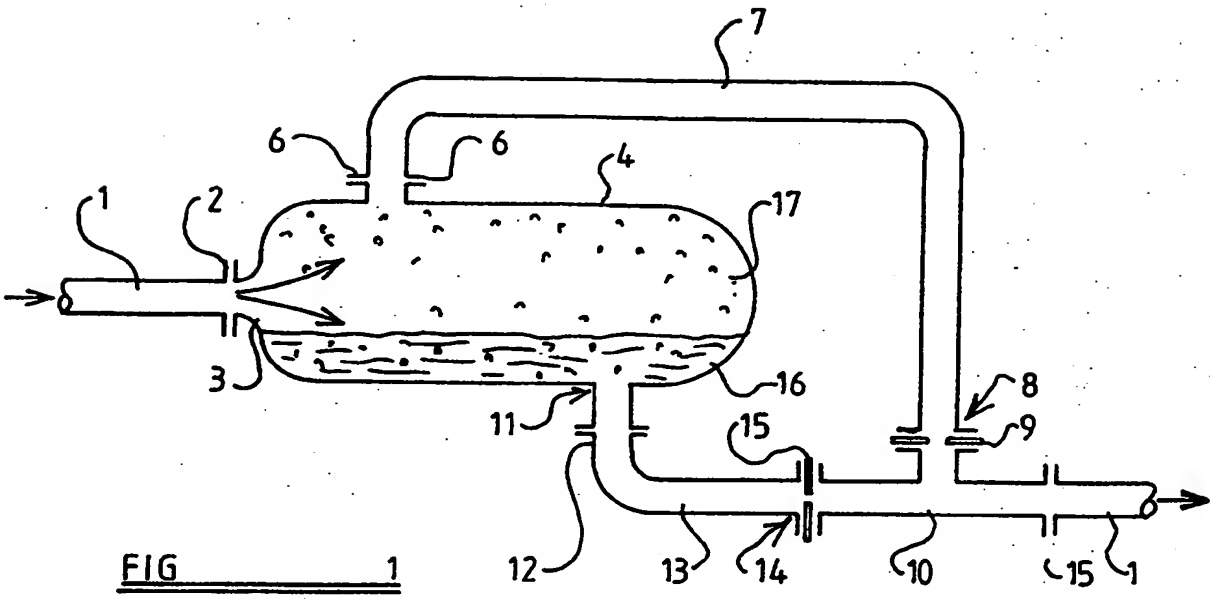

FIG 1

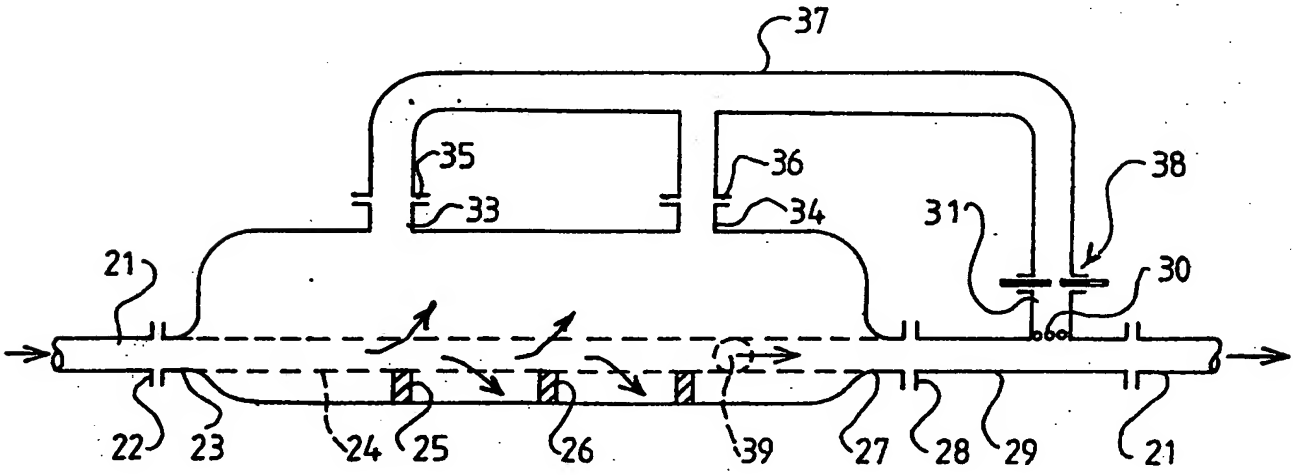

FIG 2

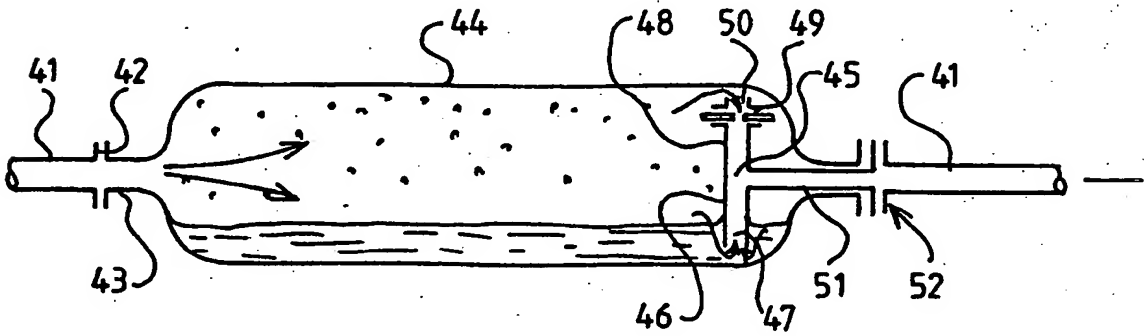

FIG 3

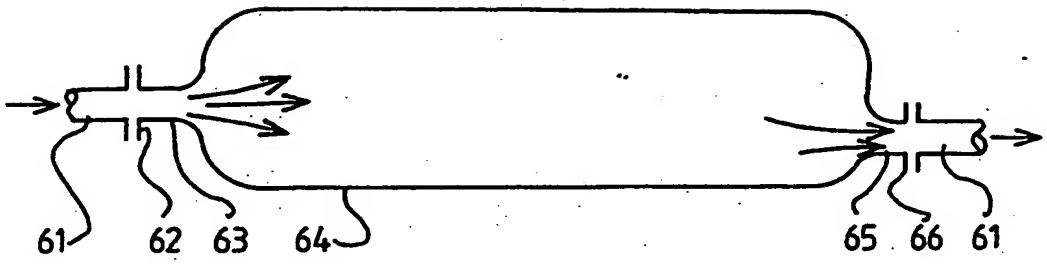

FIG 4

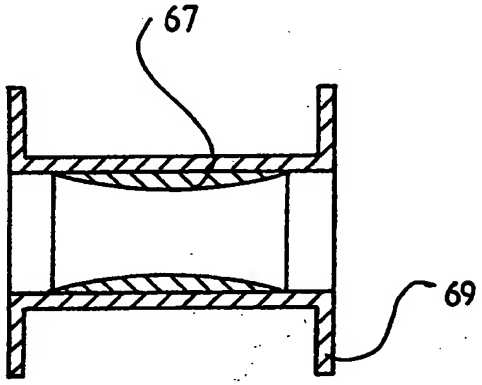

FIG 5

Description of Invention

Improvements in or relating to a flow regulating device

THE PRESENT INVENTION relates to a flow regulating device, and more particularly relates to a flow regulating device for use in a pipeline intended to carry a multi-phase liquid/gas mixture.

When a gas and liquid mixture flows through a pipeline, such as a mixture of oil and gas, the two phases have a tendency to separate under some circumstances, with the gas flowing in the upper part of the pipe, and the oil flowing in the lower part of the pipe. However, in a multi-phase system such as this, the gas usually flows faster than the oil. It sometimes happens that a wave created in the surface of the oil is propelled along the pipe faster than the general flow of oil, by virtue of the action of the gas, and the wave can increase in size, until the wave totally fills the cross-section of pipe, when it forms a so-called "slug". The gas continues to force the "slug" forwards, and the "slug" increases in size. Consequently a situation can develop where, instead of the pipe carrying an even flow of liquid and of gas, the pipe carries an intermittent flow, comprising "slugs" of oil followed by "slugs" of gas.

There are many other reasons why these "slugs" occur, but it has been found, particularly in connection with pipelines carrying gas and oil, that the "slugs" are of random size, and of intermittent frequency. It is seldom possible to predict the occurrence of such "slugs" with certainty.

It is to be appreciated that a large "slug" of oil arriving with a significant velocity at the end of a pipeline, where expensive and delicate valves and other control arrangements are provided, may cause significant damage, and may also cause operational upsets.

Various methods have been used previously for "slug" control including limiting the total length of a pipe conveying multi-phase fluids, and carefully selecting flowing conditions within the pipe to ensure that the fluids flow in a desirable manner and do not create "slugs". It has also been proposed to install a "slug catcher" or a "vapour-liquid separator" at the end of the pipeline. Essentially such a "slug catcher" is a large vessel into which the pipeline discharges. One outlet from the vessel takes the oil away for subsequent processing, and another pipeline takes the gas away for subsequent processing. Thus the vessel acts to separate the oil from the gas. The oil and the gas then effectively go their different ways.

It has also been found that the number of "slugs" created in any particular pipeline can be minimised by regularly cleaning the pipe with a so-called "pig". Typically a "pig" is a sphere which fits closely into the pipe, and is passed along with the flow of mixture in the pipe to clean the system. This operation is known as "pigging". If a "pig" is introduced to a pipeline, then appropriate apparatus must be provided at the other end of the pipeline to catch the "pig" since the "pig" will not be able to pass through the valves and control apparatus provided at the end of the pipeline.

The present invention seeks to provide a flow regulating device which can be incorporated in a pipeline with the purpose of destroying or at least reducing the size of any "slugs" created in that pipeline.

According to one aspect of the invention there is provided an apparatus for regulating the flow of a multi-phase flow of fluid through a pipeline, said apparatus being incorporated in the pipeline and comprising an inlet adapted to receive the multi-phase flow passing through the pipeline, said inlet communicating with a separation vessel of enlarged cross-section relative to the pipeline, and at least one outlet from the separation vessel connected to the continuation of the pipeline.

According to another aspect of the invention there is provided an apparatus to be incorporated in a pipeline adapted to carry a multi-phase flow to regulate that flow, said apparatus comprising an inlet adapted to receive the flow passing through the pipeline, said inlet communicating with the interior of a separation vessel having an enlarged internal cross-section relative to pipeline, said separation vessel having at least a first outlet located at or adjacent the top of the vessel to permit a gaseous phase to leave the vessel, and having a second outlet at a lower position adapted to permit the egress of a liquid phase from the vessel, the outlets each being connected to a combining means where the flows from the outlets are re-combined, the apparatus having an outlet through which the re-combined flows may pass, again entering the main pipeline.

There may be two or more of said first outlets, and/or two or more of said second outlets.

Preferably at least one of said outlets is associated with a constriction, said constriction being located at the outlet or in a conduit connected to the outlet, and conveniently both of the outlets are associated with a respective constriction.

Advantageously in the or each constriction consists of an apertured plate.

Alternatively the or each constriction may consist of a valve, and in one embodiment at least one said valve is remotely controllable.

Alternatively again the or each constriction may consist of a projection formed on the interior of a conduit defining a venturi.

Preferably the said combining means comprises a "T" connector.

Conveniently the second outlet comprises an outlet located in the bottom of the separator vessel, the first outlet and the second outlet being connected by respective conduits to said combining means.

In an alternative embodiment the first outlet is located within the separation vessel adjacent the top thereof and the second outlet is located within the separation vessel adjacent the bottom thereof, the two outlets being interconnected by a conduit within the separation vessel, which constitutes the combining means, a further conduit, carrying the combined flow, passing through an outlet of the separation vessel.

In another alternative embodiment the said inlet to the separation vessel comprises part of a perforated linear pipe which extends through the separation vessel to an outlet of the separation vessel which is axially aligned with the inlet, and comprising said second outlet.

According to a further aspect of this invention there is provided a method of regulating a multi-phase

flow in a pipeline, said method comprising the steps of causing the flow to pass through a length of the pipeline of predetermined cross-sectional area, subsequently causing the flow to pass into an enlarged cross-sectional area separation vessel, and subsequently withdrawing the two separated phases of the flow, from that separation vessel, as a re-combined flow.

According to yet another aspect of this invention there is provided a method of regulating a multi-phase flow in a pipeline, said method comprising the steps of causing the flow in the pipeline to enter a separation vessel having a greater cross-section than the cross-section of the pipeline, withdrawing one phase of the flow through an outlet located adjacent the top of the vessel, withdrawing another phase of the flow through an outlet at a lower position, and re-combining the two flows to form a single combined flow, and causing that combined flow to pass through a continuation of the pipeline.

Preferably at least one of the flows withdrawn from the said separation vessel is caused to pass through a constriction.

Conveniently both the withdrawn flows are caused to pass through a restriction.

In order that the invention might be more readily understood, and so that further features thereof may be appreciated, the invention will now be described, by way of example, with reference to the accompanying drawings in which

FIGURE 1 is a diagramatic representation of one embodiment of the invention,

FIGURE 2 is a diagramatic representation of another embodiment of the invention,

FIGURE 3 is a diagramatic representation of a further embodiment of the invention, and

FIGURE 4 is a diagramatic representation of yet another embodiment of the invention, and

FIGURE 5 is a cross-sectional view through one embodiment of a constriction which may be utilised in embodiments of the invention.

Referring initially to Figure 1 of the accompanying drawings a flow regulating device in accordance with the present invention is intended to be mounted in position in a fluid flow pipeline 1, which may have a diameter of, typically, 30cm. The pipeline, in this embodiment of the invention, is intended to carry a flow of oil and gas.

The pipeline 1 is connected, by means of typical flanged connection 2 to an inlet 3 of a separation vessel 4. Instead of flanged connections other conventional compressive connections may be used. The separation vessel can comprise a cylindrical vessel having, typically, an internal diameter of approximately 75cm. The separation vessel may typically have a length of 5.0m.

The separation vessel is provided with a first outlet 5 located in an upper region of the vessel. The outlet is formed in the side wall of the vessel at the highest point of the side wall. The outlet 5 is connected by means of a flanged connector 6 to a conduit 7. The conduit 7 terminates in a restriction 8. In this embodiment the restriction 8 is constituted by an aper-

tured plate 9 received between flanges provided at the end of the pipe 7, and further flanges provided on one arm of a "T" connector 10.

The separation vessel 4 is provided with a second outlet 11 which is located in the bottom of the vessel, that is to say at a position lower than the position of the first outlet 5. The second outlet 11 is connected by way of a flanged connector 12 to a further conduit 13, which leads to a restriction 14. In this embodiment the restriction 14 is comprised by an apertured plate 15 received between a flanged end of the conduit 13 and another arm of the "T" connector 10. The third arm of the "T" connector 10 is connected, by way of a flanged connection 15, to a continuation of the pipeline 1.

The conduit 7 and the conduit 13 may both have an internal diameter of approximately 30cm.

The sizes of the restrictions defined by the apertured plates 9 and 15 are such that the total cross-sectional area defined by the apertures is usually at least equivalent to the cross-sectional area of a conduit having an internal diamter of 30cm. The relative sizes of the apertures will be selected in dependence upon the nature of the multi-phase mixture that is to flow through the pipeline 1. If that multi-phase mixture has a large gas content and a low liquid content the aperture in the plate 9 will be larger than the aperture in the plate 15, whereas if the multi-phase mixture has a larger liquid content than gas content, then the aperture in the plate 15 will be larger than the aperture in the plate 9.

The skilled man will readily be able to determine the appropriate sizes for the apertures for any

particular mixture in the light of the following explanation of the mode of operation of the device.

When the pipeline 1 carries a uniform flow of both oil and gas, the two phases enter the inlet 3 of the separation vessel 4 in a uniform manner, with the oil tending to flow towards the bottom of the vessel, where it will form a pool 16 of oil, and the gas tending to flow towards the top of the vessel, so that the upper part 17 of the vessel is filled with gas. Some gas will remain trapped in the oil in the form of bubbles, and the oil may not remain in the separation vessel long enough for complete separation to take place.

Gas from the upper part of the separation vessel 4 will leave the vessel by means of the outlet 5 and will flow through the conduit 7, and through the restriction 8 into the "T" piece 10. Similarly oil will leave the separation vessel 4 through the outlet 11, and will flow through the conduit 13 and the restriction 14 to the "T" piece 10. The flow of oil will then, in the "T" piece 10, be re-combined with the flow of gas, so that a uniform flow leaves the described arrangement through the continuation of the pipeline 1.

Should a "slug" of oil be flowing down the pipe, the "slug" of oil will enter the separation vessel 4, thus enlarging the pool of oil 16. However, the oil will, due to the effect of gravity, tend to settle, and the gas already present within the vessel will continue to leave through the outlet 5. Following the "slug" of oil there will, usually, be a "slug" of gas. Whilst this "slug" of gas is being received within the separation vessel 4 the enlarged pool 16 of oil will be draining away through the outlet 11, and at all times a steady flow of gas will pass through the constriction 8 and a substantially steady flow of oil will pass through

the constriction 14, thus ensuring that a substantially uniform flow of separated oil and gas continues to flow through the extension of the pipeline 1.

Should, as may sometimes (although very rarely) be the case that a very large "slug" of oil should arrive, then the "slug" may completely fill the separation vessel 17 and oil may leave the separation vessel through the outlet 5 as well as through the outlet 11. Since the total cross-sectional area of the restrictions 8 and 14 is usually the same as the cross-sectional area of the inlet 3 to the separation vessel, all the oil entering the separation vessel will be able to leave the described apparatus without effecting any damage to the apparatus. A similar effect is obtained if a very large "slug" of gas should arrive.

In alternative embodiments there may be two or more gas outlets and/or two or more oil outlets from the separation vessel.

Referring now to Figure 2 of the accompanying drawings, a modified embodiment of the invention is illustrated which is adapted to accommodate a "pig".

In the embodiment illustrated in Figure 2, a pipeline 21 is connected by means of a flanged connector 22 to an inlet 23 of a length of perforated pipe 24 which passes through an enlarged diameter separation vessel 25. The pipe 24 may be supported within the separation vessel by means of a plurality of supports 26. The perforated pipe 24 passes completely through the separation vessel 25 emerging at an outlet 27 which is connected, by means of a flange connector 28, to one arm of a barred "T" connector 29 having a plurality of bars 30 extending across one arm 31 thereof.

The upper part of the separation vessel 25 is provided, in this embodiment, with two outlets 33,34 which are connected by means of flanged connectors 35,36 to a gas-carrying conduit 37 which is connected, by means of a restriction 38 to the said barred arm 31 of the "T" connector 29. The remaining arm of the "T" connector 29 is connected to an extension of the pipeline 21.

It will be appreciated that, in this embodiment of the invention, the pipeline 21 is connected directly to the perforated pipe 24 which in turn is connected to a linear portion of the "T" connector 29 which in turn is connected to the continuation of the pipeline 21 and thus a spherical "pig", such as the "pig" 39 may be caused to pass through the apparatus, effecting a cleaning of the apparatus and the associated pipeline. The bars 30 provided in the barred "T" connector 29 serve to prevent the "pig" from entering the arm 31 of that connector, thus ensuring that the "pig" continues to move down the main pipeline.

It will be appreciated that this embodiment of the invention will operate in a manner very similar to that described with reference to Figure 1. If an even flow of gas and oil is flowing through the pipeline 21, then that even flow will pass through the inlet 23 to the perforated pipe 24, with the oil continuing to flow through the perforated pipe 24. A pool of oil will be formed in the lower part of the separation vessel. The pool may have such a depth that the perforated pipe 24 is totally submerged. Oil from this pool will drain away through outlet 27. The gas will pass through the perforations into the upper part of the separation vessel and then will flow through the outlets 33 and 34, and through the conduit 37 to be re-combined with the oil in the "T" connector 29.

However, in the event of a "slug" of oil arriving, some of the "slug" will enlarge the pool of oil within the separation vessel, and subsequently that pool of oil will flow away through the outlet 27, while the gas that will follow the "slug" will flow through the outlets 33 and 34, and all the time there will be a steady re-combined flow of gas and oil leaving the "T" connector 29.

It will be appreciated, however, that a device of this type may be utilised in pipelines where it is essential to carry out a "pigging" operation.

Referring now to Figure 3 of the accompanying drawings a further embodiment of the invention is illustrated in which a pipeline 41 is connected by means of flange connector 42 to an inlet 43 of an enlarged diameter separation vessel 44. A "T" piece connector 45 is mounted within the separation vessel, with one arm 46 directed downwardly, presenting an inlet 47 located adjacent the bottom of the separation vessel 44, and having another arm 48 directed upwardly. The arm 48 terminates in a constriction 49, of the apertured plate type described above, and presents an open inlet 50 which is adjacent the top of the separation vessel.

The third arm 51 of the "T" piece connector 45 passes through the outlet of the separation vessel 44 and is connected, by means of a flanged connector 52 to a continuation of the pipe 41.

Again this embodiment of the invention will operate in a manner very similar to that described above, with a uniform flow of oil and gas passing uniformly through the device, and a "slug" of oil causing an enlarged pool of oil to accumulate within the separation vessel 44, with the result that gas and oil are both

continually drawn into the "T" piece 45 and are re-combined to produce a flow having desired flow characteristics.

Whilst the invention has been described above with reference to embodiments in which the separation vessel is provided with separate outlets for the gas and oil, so that the gas and oil may be withdrawn from the interior of the separation vessel through separate outlets, the gas and oil subsequently being re-combined to form a stream having desired flow characteristics, it is envisaged that a very simple embodiment of the invention may be provided as illustrated in Figure 4, in which a pipe 61 carrying a two-phase stream of gas and liquid is connected, by a flanged connection 62, to an inlet 63 of an cylindrical enlarged diameter separation vessel 64 generally as described above, the separation vessel having an outlet 65 connected by means of a flanged connector 66 to a continuation of the pipeline 61. It will be appreciated that such an arrangement will operate satisfactorily under uniform flow conditions, and will also serve to substantially even-out any "slugs" that may arise.

Whilst the invention has been described with reference to restrictions constituted by apertured plates mounted between flanged couplings between lengths of pipe or conduit, it is to be appreciated that other types of restriction may be used. Thus the restrictions may comprise valves or the like. If valves are utilised the valves may be pre-set, and thus the arrangement incorporating valves will have the same advantage as the arrangement incorporating apertured plates, in that once the apparatus is installed there are no moving parts, and thus there is nothing to go wrong. However, in certain circumstances, where a pipeline carries different mixtures having different pro-

portions of oil to gas, it may be desirable to include adjustable restrictions, such as restrictions which may be adjustable remotely. Thus, when a pipeline is to carry a different type of mixture, the relative dimensions of the restrictions may be adjusted remotely before the new flow commences.

Figure 5 illustrates one alternative form of constriction which may be utilised in a conduit, the restriction effectively comprising a projection 67 formed on the interior of the pipe forming a venturi in the direction 68 of fluid flow. The constriction is to be mounted in the conduit by the flanged connectors 69. Such a restriction may prove desirable in the position occupied by the constriction 14 as shown in Figure 1, since the presence of the venturi will cause the oil to accelerate, thus enabling the oil to be readily constrained to flow with the gas entering the "T" piece connector, thus in turn ensuring that a uniform flow leaves the apparatus to continue to flow down the main pipeline. Of course, other types of constriction may be utilised if desired.

Whilst the invention has been described with reference to flow regulating devices which can be incorporated in a pipeline adapted to carry oil and gas, and whilst those flow regulating devices are suitable for mounting in position on the sea-bed or anywhere else that the pipeline may go, it is to be appreciated that embodiments of the invention may find other uses. For example it is envisaged that embodiments of the invention may be incorporated in a chemical production plant where multi-phase flows occur and may also be utilised in such situations as steam heating systems where a multi-phase steam water flow can occur.

It is envisaged that a long length of pipeline

may require several flow regulating devices in accordance with the invention at space apart positions along the length of the pipeline. Whilst the invention has been described with reference to specific sizes in one embodiment it is to be appreciated that embodiments of the invention may have any appropriate size for the specific function to be performed.

CLAIMS:

1. An apparatus for regulating the flow of a multi-phase flow of fluid through a pipeline, said apparatus being incorporated in the pipeline and comprising an inlet adapted to receive the multi-phase flow passing through the pipeline, said inlet communicating with a separation vessel of enlarged cross-section relative to the pipeline, and at least one outlet from the separation vessel connected to the continuation of the pipeline.

2. An apparatus to be incorporated in a pipeline adapted to carry a multi-phase flow to regulate that flow, said apparatus comprising an inlet adapted to receive the flow passing through the pipeline, said inlet communicating with the interior of a separation vessel having an enlarged internal cross-section relative to pipeline, said separation vessel having at least a first outlet located at or adjacent the top of the vessel to permit a gaseous phase to leave the vessel, and having a second outlet at a lower position adapted to permit the egress of a liquid phase from the vessel, the outlets each being connected to a combining means where the flows from the outlets are re-combined, the apparatus having an outlet through which the re-combined flows may pass, again entering the main pipeline.

3. An apparatus according to Claim 2 wherein there are two or more of said first outlets.

4. An apparatus according to according to Claim 3 where there are two or more of said second outlets.

5. An apparatus according to any one of Claims 2

to 4 wherein at least one of said outlets is associated with a constriction, said constriction being located at the outlet or in a conduit connected to the outlet.

6. An apparatus according to Claim 5 wherein both of the outlets are associated with a respective constriction.

7. An apparatus according to Claim 5 or Claim 6 wherein the or each constriction consists of an apertured plate.

8. An apparatus according to Claim 5 or Claim 6 wherein the or each constriction consists of a valve.

9. An apparatus according to Claim 8 wherein at least one said valve is remotely controllable.

10. An apparatus according to Claim 5 or Claim 6 wherein the or each constriction consists of a projection formed on the interior of a conduit defining a venturi.

11. An apparatus according to any one of the Claims 2 to 10 wherein the said combining means comprises a "T" connector.

12. An apparatus according to any one of Claims 2 to 11 wherein the second outlet comprises an outlet located in the bottom of the separator vessel, the first outlet and the second outlet being connected by respective conduits to said combining means.

13. An apparatus according to any one of Claims 2 to 11 wherein the first outlet is located within the separation vessel adjacent the top thereof and the second outlet is located within the separation vessel

adjacent the bottom thereof, the two outlets being interconnected by a conduit within the separation vessel, which constitutes the combining means, a further conduit, carrying the combined flow, passing through an outlet of the separation vessel.

14. An apparatus according to any one of Claims 2 to 11 wherein the said inlet to the separation vessel comprises part of a perforated linear pipe which extends through the separation vessel to an outlet of the separation vessel which is axially aligned with the inlet, and comprising said second outlet.

15. A method of regulating a multi-phase flow in a pipeline, said method comprising the steps of causing the flow to pass through a length of the pipeline of predetermined cross-sectional area, subsequently causing the flow to pass into an enlarged cross-sectional area separation vessel, and subsequently withdrawing the two separated phases of the flow, from that separation vessel, as a re-combined flow.

16. A method of regulating a multi-phase flow in a pipeline, said method comprising the steps of causing the flow in the pipeline to enter a separation vessel having a greater cross-section than the cross-section of the pipeline, withdrawing one phase of the flow through an outlet located adjacent the top of the vessel, withdrawing another phase of the flow through an outlet at a lower position, and re-combining the two flows to form a single combined flow, and causing that combined flow to pass through a continuation of the pipeline.

17. A method according to Claim 16 wherein at least one of the flows withdrawn from the said separation vessel is caused to pass through a constriction.

18. A method according to Claim 17 wherein both the withdrawn flows are caused to pass through a restriction.

19. An apparatus for regulating a multi-phase flow substantially as herein described with reference to and as shown in Figure 1 of the accompanying drawings.

20. An apparatus for regulating a multi-phase flow substantially as herein described with reference to and as shown in Figure 2 of the accompanying drawings.

21. An apparatus for regulating a multi-phase flow substantially as herein described with reference to and as shown in Figure 3 of the accompanying drawings.

22. An apparatus for regulating a multi-phase flow substantially as herein described with reference to and as shown in Figure 4 of the accompanying drawings.

23. A method of regulating a multi-phase flow substantially as herein described with reference to Figure 1 of the accompanying drawings.

24. A method of regulating a multi-phase flow substantially as herein described with reference to Figure 2 of the accompanying drawings.

25. A method of regulating a mult-phase flow substantially as herein described with reference to Figure 3 of the accompanying drawings.

26. A method of regulating a multi-phase flow substantially as herein described with reference to Figure 4 of the accompanying drawings.

27. Any novel feature or combination of features

disclosed herein.

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